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ORIGINAL ARTICLE

The diagnostic role of thoracoscope in undiagnosed pleural effusion: Rigid versus flexible



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Abstract *Objectives:* The accurate diagnosis of pleural diseases can present a considerable challenge. Conservative estimates suggest that in 25% of patients examined in a general pulmonologist's practice the pleura was involved. Of these cases, 25% are unable to be attributed to a specific diagnosis, even after thoracentesis and closed pleural biopsy. The aim of this work was to evaluate the diagnostic role of medical thoracoscope in undiagnosed exudative pleural effusion and to compare the diagnostic yield of rigid versus flexible (the fibreoptic bronchoscope used as a thoracoscope) thoracoscopy.

Patients and methods: Forty patients with exudative pleural effusion of undetermined aetiology were enrolled in this study. Ethics: the study was approved by the institutional ethics committee and each patient gave an informed consent to participate in the study. Under conscious sedation and local anaesthesia, both rigid and flexible thoracoscopy were carried out using fibreoptic bronchoscope as a flexible thoracoscope inserted through a metal trocar. The pleural cavity was carefully explored and multiple forceps biopsies were equally taken with both types of thoroscopes and sent for both histopathological and microbiological examinations.

Results: All thoracoscopy procedures were performed safely. The diagnostic yield of flexible thoracoscope and that of rigid thoracoscope was 80% (32/40) and 95% (38/40), respectively.

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Conclusions: Thoracoscopy using either fiberoptic bronchoscope or rigid thoracoscope is safe and well tolerated. Rigid thoracoscope has a higher diagnostic yield, easier handling, better orientation and is less expensive. Nevertheless, fiberoptic bronchoscope is an alternative technique if rigid thoracoscopy is not available.

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Introduction

The accurate diagnosis of pleural disease can present a considerable challenge [1,2]. Conservative estimates suggest that 25% of patients seen in a general pulmonologist's practice involve the pleura. Of these cases, 25% are unable to be attributed to a specific diagnosis, even after thoracentesis and closed pleural biopsy [3–8]. As many as 50% of the patients in this undiagnosed group will eventually be diagnosed with a malignancy [9]. If the facilities for medical thoracoscopy are available, medical thoracoscopy should be performed on these undiagnosed patients because of its high sensitivity in malignant and tuberculous pleural effusions [10]. That is why the last decade witnessed an overwhelming interest in pleuroscopy as a tool for pleural diseases [11].

Medical thoracoscopy, in the trained hands of a pulmonologist is a safe and effective procedure for the diagnosis and therapy of multiple pleural diseases [12]. It is usually performed in a bronchoscopy suite, under local anaesthetic and conscious sedation, with routine cardiopulmonary monitoring and without intubation or mechanical ventilation [13]. The diagnostic yield is in the order of 91–95% for malignant diseases and can be as high as 100% for pleural tuberculosis [5,14–16].

In the past, medical thoracoscopy was mostly performed with rigid instruments [17,18], that might have been considered relatively invasive in the setting of local anaesthesia and conscious sedation. Moreover, without addition of an extra entry port, the posterior and mediastinal aspects of the hemithorax are difficult to access using a rigid thoracoscope, especially when a lung was only partially collapsed [19]. Furthermore, most respiratory physicians are not familiar with rigid instruments and hence the procedure was not popular [13].

The use of a flexible fiberoptic instrument to examine the pleural space was reported by Senno et al. in the 1970s in the United States. Studies showed that flexible bronchoscope when used as thoracoscope maintains a clear optical field by allowing concurrent suctioning, which is analogous to the suction techniques used during flexible bronchoscopy [20] and better views at the apex and paravertebral gutters [21,22]. This technique, had been termed “pleuroscopy” as well [23].

The aim of this work was to evaluate the role of flexible bronchoscope used as a thoracoscope versus rigid thoracoscope in the diagnosis of exudative pleural effusion of unknown aetiology.

Patients and methods

Thoracoscopy was performed on 40 consecutive patients who presented to Alexandria Main University Hospital, Chest department with exudative pleural effusion of unclear

aetiology. All patients underwent thoracentesis at least once. The pleural effusion was exudative by Light's criteria [24].

We included patients that were fit for the procedure with good performance status, however, breathlessness alone was not necessarily a contraindication as dyspnoea secondary to the effusion was relieved by the procedure. Patients were able to tolerate lying on their side for the duration of the procedure. International normalised ratio (INR) < 2, oxygen saturation > 90% with additional oxygen during the procedure were required. We excluded patients in whom the lung was adherent to the chest wall throughout the hemithorax, patients with severe respiratory distress, uncontrollable cough and lack of informed consent.

All patients underwent initial clinical assessment, electrocardiogram (ECG), routine blood chemistry analysis, chest X-ray, thoracentesis, contrast enhanced computed tomography (CT) and ultrasonography. Data collected include patient demographics, clinical status, detailed medical history, including smoking habits, exposure to asbestos, and history of previous cancer.

Thoracoscopy was performed in the bronchoscopy suite, with the patient under conscious sedation and local anaesthesia. Intravenous midazolam was used and titrated according to patients' needs. All patients were subjected to examination using both a rigid thoracoscope and a fiberoptic bronchoscope. Patients were monitored regarding blood pressure, pulse rate, an electrocardiograph was attached, pulse oximeter, supplementary oxygen was provided to maintain oxygen saturation > 90%.

Equipment used included a rigid thoracoscope (Karl Storz, Germany), a straight forward telescope 0° with angled eyepiece, 10 mm in diameter, working length at 27 cm with 6 mm working channel, fiberoptic bronchoscope, (PENTAX, fiberoptic bronchoscope), a metallic trocar 11 mm in diameter, cold (xenon) light source, an endoscopic camera attached to the eye-piece, video monitor and recorder and other accessories commonly available in a chest tube insertion tray. A single port of entry was required in all patients.

The patient was positioned in the lateral decubitus position breathing spontaneously, with the normal lung in the dependent position and the arm raised above the head. Two patients were very difficult to be operated due to difficult positioning, one was a 80 year old patient with untreated fracture neck femur, the procedure was performed in a supine semi sitting position because she could not lie on her side. Another patient had a severe burn affecting her chest wall, absent breast and extending to her arm and shoulder resulting in severe contracture and very limited abduction on the same side of effusion together with severe lymphedema of the affected arm that was lifted with difficulty and hung on a stand till the end of the procedure causing severe discomfort for both the doctor and the patient.

The involved side of the chest was disinfected; 15–30 mL of lidocaine 2% was injected at the point of entry, through all layers of chest wall till the pleura. Thoracentesis to confirm the presence of pleural fluid at the insertion site was done. A single puncture, which involved a 1-cm incision in the mid-axillary line between the 4th and 7th intercostal spaces of the chest wall was done, and a track was created by blunt dissection. A trocar was inserted and the pleural cavity opened to atmospheric pressure, any remaining pleural fluid was aspirated. A full examination of the pleural cavity was then made and biopsy specimens of parietal pleura were taken as appropriate under direct vision. Multiple (5–7) biopsy samples were taken with each instrument to avoid any bias towards one technique or another. In fact, it took a longer time to obtain equal number of biopsies using the flexible thoracoscope.

At the end of the procedure, a chest tube was inserted and lung expansion was radiographically confirmed before removal of the tube. A chest radiograph was taken within 24 h. In cases with suspected malignant lesions, pleurodesis was done after lung expansion when the pleural fluid drained was less than 100 cc/day, using iodopovidone (10% concentration). Patients were put under close observation post thoracoscopy, any complication was reported and dealt with.

The specimens obtained with the two instruments were processed separately. They were fixed in 10% neutral buffered formalin. The specimen sent for microbiology was put separately in normal saline. Subsequently all sections were examined in a random order by the pathologist blindly without knowledge of biopsy method but knowing the clinical data.

A final diagnosis was then made in light of the biopsy findings regarding both histopathological and microbiological examinations and further investigations according to individual patient circumstances and the subsequent clinical course.

Results

The study period extended from July 2011 till October 2012. Forty patients were enrolled including 15 males (37.5%) and 25 females (62.5%) presenting with undiagnosed exudative pleural effusion. Medical thoracoscopy was performed for diagnostic purposes using both rigid thoracoscope and flexible fiberoptic bronchoscope as a flexible thoracoscope. The mean age of our patients was 53 years (range 26–72). The main complaint at presentation was dyspnoea in the majority of the patients (92.5%).

Regarding the gross appearance of pleural fluid, 19 patients presented with hemorrhagic effusion (47.5%), 20 (50%) presented with straw coloured and one (2.5%) presented with green coloured pleural effusion. The majority (79%) of patients with hemorrhagic effusions were finally diagnosed as malignant, other diagnoses were tuberculous and parapneumonic effusions. So the bloody appearance of the pleural fluid narrowed the differential diagnosis predicting the malignant nature of the effusion in most of the patients. Lymphocytic predominant effusion was found in 21 patients (52.5%), most of these were diagnosed as malignant (15 out of 21) (71%) or tuberculous (five out of 21) (24%) and one patient remained idiopathic. Whereas pleural effusion showed neutrophilic predominance in 19 patients (47.5%) and those were diagnosed as follows: nine malignant (47%), seven tuberculous (37%), two

empyema (10.5%) and one patient was finally diagnosed as brucellosis (5%).

Pleural fluid cytology showed positive results for malignancy in eight patients out of 23 patients finally diagnosed as malignant pleural effusion (diagnostic yield 35%) prethoracoscopy. Although being positive in these eight patients, we still performed thoracoscopy as the pathology only described them as positive for malignant cells without mentioning the type of malignancy or its primary. All the drained pleural fluid post thoracoscopy was sent again for repeated cytology after centrifugation, another four patients turned positive for malignant cells (diagnostic yield increased to 52%). A third sample of pleural fluid was sent for cytology in only one patient whose thorascopic pleural biopsy showed histological diagnosis of fibrinous pleurisy by biopsies from both rigid and flexible thorascopes (false negative for malignancy) and presented 2 months after thoracoscopy with recurrent pleural effusion, this aided in the diagnosis of one extra patient (overall positive cytology results after repeated tapping were 13 out of 23 patients) (56.5%).

Chest X-ray and CT were done before thoracoscopy to all studied patients; 20 patients (50%) had right sided pleural effusion, 15 patients (37.5%) had left sided effusion and five patients (12.5%) had bilateral effusion. Patients with bilateral pleural effusion were finally diagnosed as tuberculous in two, combined malignancy and tuberculosis in one, metastatic adenocarcinoma from cancer breast in one and the last patient was diagnosed as brucellosis. Amount of effusion was massive in 20 patients (50%), moderate in 18 (45%) and mild only in two (5%) patients.

All thoracoscopy procedures were performed safely without serious complications. Pain was a frequent complaint during the procedure (13 out of 40 patients [32.5%]). In general, patients found that the procedure caused only minor discomfort. Moderate pain occurred when the parietal pleura was touched, transient sharp pain was experienced as biopsy was performed on unanaesthetised pleura, but to a much lesser extent when using flexible bronchoscope. Pain was also felt during chest tube insertion. Significant desaturation (more than 4%) occurred in seven patients (17.5%) with the least oxygen saturation level reaching 80% despite routine administration of oxygen therapy. In fact, this was very transient and was spontaneously corrected. Mild pulmonary oedema was suspected in these patients but none of these was radiologically confirmed. Bleeding occurred only in two patients, it was trivial and required no intervention. Arrhythmia (supraventricular tachycardia) occurred in one patient (2.5%).

Sixteen patients (40%) complained of postoperative pain that was usually mild and responded to simple analgesics. Fever (more than 38 °C) occurred in three patients (7.5%). It was transient and resolved in less than 48 h, two of them (tuberculous) developed pleurocutaneous fistulae as well. The three patients were diabetics and their final diagnosis was tuberculous pleural effusion. Four patients (10%) were found to have complications by surgical emphysema. Also, pneumothorax was a postoperative complication in seven patients (17.5%).

Other complications as malignant seedling of the wound, pulmonary embolism, empyema and respiratory failure were not encountered in our patients despite not giving prophylactic anticoagulants, antibiotics or radiotherapy. Even the two patients from whom visceral pleural biopsy was taken did not develop persistent air leak. There was no reported mortality

related to the procedures. Nevertheless, seven patients died from reasons not related to the procedure during the study period.

A rigid thoracoscope was compared to fibreoptic bronchoscope used as a flexible thoracoscope and the diagnostic adequacy of biopsy specimens obtained with the two instruments was assessed. The two instruments were inserted in the bronchoscopy suite using local anaesthesia. Both types were easy to handle. The image quality was uniformly excellent using rigid thoracoscopy but not that good using fibreoptic bronchoscopy, [Figs. 1 and 2](#). Pleural fluid was suctioned without difficulty in both types, but fibreoptic bronchoscope allowed concurrent suctioning. Pain experienced during the procedure was never severe, but in comparison to flexible bronchoscope, both the manoeuvring of the rigid thoracoscope and taking biopsies with the rigid forceps were a little more painful and caused more patient discomfort. This was transient and outweighed by the shorter duration required to fully inspect the pleural space and take biopsies from suspicious lesions. The flexibility of the fibreoptic bronchoscope made orientation and biopsy taking more difficult.

The specimens obtained with the rigid instrument were larger (mean size 11 mm versus 2.5 mm) than those taken by the flexible bronchoscopy, [Fig. 3](#). The larger specimens provided an added degree of certainty in diagnosis. In fact, histopathology reports after examining rigid instrument specimens never included the terms “inadequate” or “suspicious” which was a common finding in reports from biopsies obtained using the flexible instrument.

Comparing biopsy specimens obtained with both instruments, the histological features were considered identical in 25 patients; specimens obtained with the fibreoptic bronchoscope were more informative in two patients. In one patient histopathology was reported as fibrinous pleurisy using flexible thoracoscope (reported as crushed tissues by rigid thoracoscope forceps), another patient flexible thoracoscope diagnosed metastatic non small cell carcinoma in a patient with extensive adhesions which prevented the entrance of rigid thoracoscope and those obtained from the rigid thoracoscope were more informative in 13 patients ([Table 1](#)). Furthermore, the diagnostic yield (after combining both histopathology

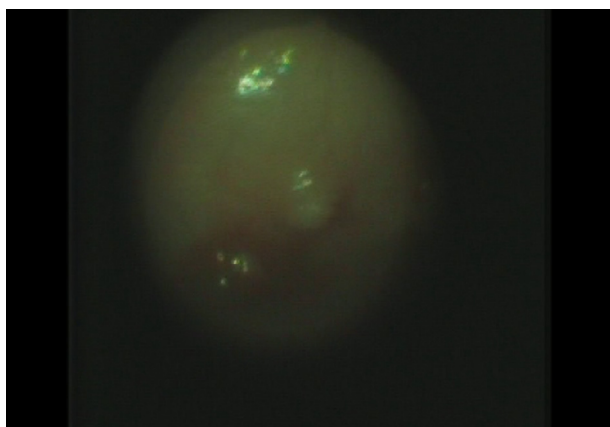


Figure 1 Thoracoscopic view using fibreoptic bronchoscope showing whitish yellow nodules of different sizes in a case of metastatic adenocarcinoma from cancer colon.

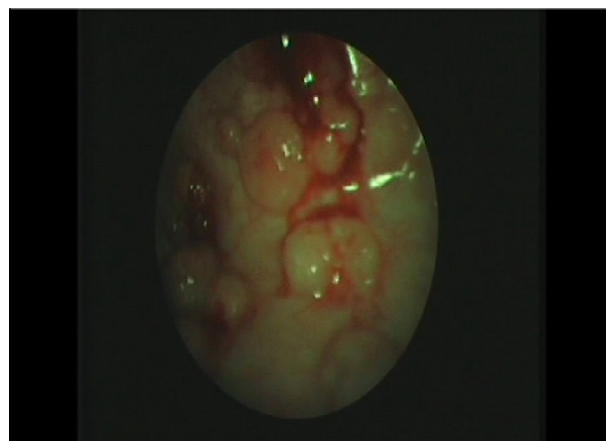


Figure 2 Thoracoscopic view using rigid thoracoscope in the same patient.

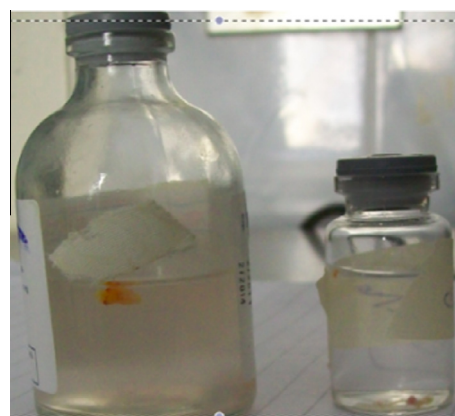


Figure 3 Showing larger biopsy size obtained by rigid thoracoscope forceps (left) in comparison to the small size (right) obtained by flexible thoracoscopy.

and bacteriology results) obtained using the rigid thoracoscope (95%) was significantly higher than the flexible one (80%). It is also important to note that the microbiologist preferred larger biopsies obtained by the rigid forceps using rigid thoracoscope for direct smear staining for acid-fast bacilli.

Eventually after combining the results of both types of thoroscopes, observing clinical course of the patient, and adding additional investigations as needed, only one patient remained idiopathic (2.5%).

Discussion

The study enrolled 40 patients who underwent medical thoracoscopy with both rigid thoracoscope and flexible fibreoptic bronchoscope as a flexible thoracoscope for diagnosis of patients presenting with exudative pleural effusions in which initial diagnostic work-up with pleural fluid analysis was inconclusive. The 40 patients included 25 female patients (62.5%) and 15 male patients (37.5%). The median age of the patients was 53 years (range: 26–72).

In our hands thoracoscopy under local anaesthesia with low doses of midazolam was well tolerated by the patients.

Table 1 Comparison between histopathologic results obtained by both fibreoptic bronchoscope and rigid thoracoscope and the final diagnosis after adding results of bacteriological examination and further investigations.

| Fibreoptic bronchoscope | Rigid thoracoscope | Final diagnosis |
|--|---|--|
| <i>Thoracoscope better than bronchoscope</i> | | 13 |
| 5 Fibrinous pleurisy | 3 Metastatic carcinoma 1 Mesothelioma | 3 Metastatic carcinoma 1 Mesothelioma |
| 5 Inadequate biopsies | 1 Caseating granuloma 2 Metastatic carcinoma 3 Fibrinous pleurisy | 1 TB 1 Metastatic carcinoma 1 TB and metastatic carcinoma 1 Idiopathic 2 TB |
| 3 Suspicion of malignancy | 3 Metastatic carcinoma | 1 Metastatic carcinoma 2 TB and Metastatic carcinoma 2 |
| <i>Bronchoscope better than thoracoscope</i> | | 1 Metastatic non small cell carcinoma |
| 1 Metastatic non small cell carcinoma | 1 Failure of introduction | 1 TB |
| 1 Fibrinous pleurisy | 1 Crushed tissues | 25 |
| <i>Thoracoscope and bronchoscope identical</i> | | 2 TB |
| 2 Caseating granuloma | | 1 TB and mesothelioma 1 Mesothelioma |
| 2 Mesothelioma | | 1 TB and metastatic carcinoma 9 Metastatic carcinoma |
| 10 Metastatic carcinoma | | 7 TB 1 Complicated parapneumonic effusion 1 Malignant (by cytology) 1 Brucellosis |
| 10 Fibrinous pleurisy | | 1 Tuberculous empyema |
| 1 Septic pleurisy | | |

No major complications were reported; minor complications (fever, surgical emphysema, pleurocutaneous fistula, persistent pneumothorax) were reported in 12 out of 40 patients (30%). This represents high incidence of minor, but not major complications in relation to others. One study [3] reported major complication (death, hypercapnic respiratory failure, empyema, sepsis, pulmonary embolism) and minor complication (clinically insignificant pneumothorax, subcutaneous emphysema, fever, pain requiring opiates) rates of 1.9% and 5.5%, respectively. Bleeding from the parietal pleural biopsy site was observed in only one of our patients and was trivial and rapidly ceased. Direct pressure was applied from the inside; using gauze mounted on a forceps, surgical intervention was not needed. This is in contrast to another study [25] that showed that the most common and severe complication following medical thoracoscopy was massive bleeding. Others reported 0.3–0.4% incidence of major bleeding [26]. The chance of bleeding was minimal in our study, as the least prothrombin activity and INR among studied patients were 59% and 1.4%, respectively. Biopsy was taken from the parietal pleura against the ribs (to avoid injury to intercostal vessels). Bleeding was not encountered using flexible biopsy forceps. Significant oxygen desaturation ($>4\%$) was reported in seven patients (17%). The least oxygen saturation was 80% but this was very transient and spontaneously corrected. These seven patients having significant desaturation together with cough and chest discomfort were clinically suspected to have reexpansion pulmonary oedema but with no radiological evidence. There was no procedure related mortality among our patients, this matches the results of other studies which report that death as a complication is extremely rare, only one fatality out of 8000 patients was reported in one series [7]. Nevertheless, in our study seven patients died at a later stage from reasons not related to the procedure.

Comparing both flexible and rigid thoracoscopy, both were easy to handle, but the rigid thoracoscopy was superior in several aspects. The image quality was excellent and superior to that seen using fibreoptic bronchoscopy, with easier control and manoeuvring of the instrument. Flexibility of the fibreoptic bronchoscope made it difficult to control and manoeuvre. Rigid thoracoscope provided good orientation which was not the case using the flexible one, since a fixed anatomical guidance as in the tracheobronchial tree is not present as reported by other studies [27]. Rigid thoracoscopy was able to visualise most of the pleura, but not that part of costal pleura near insertion site and posteriorly near the paravertebral gutter. Actually this was not a big problem because in nearly all our patients, there were multiple sites of pleural affection. On the other hand, using flexible bronchoscope, there was difficulty in inspection of the pleural cavity in the presence of adhesions noting that adhesions were a common thoracoscopic finding among our patients, as their disruption was extremely difficult. The rigid thoracoscope was more suitable when more elaborate procedures were indicated as bleeding control or adhesiolysis. These findings match with those of previous studies [21,28,29]. As for biopsy taking, it was much easier, less time consuming using the rigid thoracoscope forceps. Rigid thoracoscope provided larger biopsies (mean size 11 mm versus 2.5 mm, $p < 0.005$), as biopsy size obtained by the flexible bronchoscope biopsy was limited by the small size of its working channel. Flexible forceps also lack mechanical strength in obtaining pleural specimens of sufficient depth, a major factor that affects yield when mesothelioma is suspected. In our study, rigid thoracoscopy was superior in diagnosing one more patient as mesothelioma that was not diagnosed by the fibreoptic bronchoscope (fibrinous pleurisy). The superiority of rigid thoracoscopy in diagnosis of mesothelioma was shown in a previous study [21]. This technical problem could be overcome

by taking multiple biopsies (range: 5–10) of the abnormal areas as well as several “bites” of the same area to obtain tissues of sufficient depth. Full thickness parietal pleural biopsies can be achieved using the insulated tip (IT) diathermic knife during flex-rigid pleuroscopy. In one study, the reported diagnostic yields were 85% with IT knife, compared with 60% with flexible forceps [30]. The larger specimens provided an added degree of certainty in diagnosis. Similarly, Davidson et al. [21] reported their experience and concluded that the biopsies obtained by the rigid forceps, which were much larger, were more informative. This has certainly been our experience. Some difficulty was experienced in obtaining biopsy specimens from smooth pleura with the flexible forceps due to forceps slipping. This was encountered in one patient resulting in a specimen that was not suitable for pathological examination (inadequate). Pain experienced during the procedure was never severe, but in comparison to flexible bronchoscope, both the manoeuvring of the rigid thoracoscope and taking biopsies with the rigid forceps were a little more painful and caused more patient discomfort. Nevertheless, this was transient and outweighed by the shorter duration required to fully inspect the pleural space and take adequate biopsies from suspicious lesions. Pleural fluid was suctioned without difficulty in both types, but fibreoptic bronchoscope allowed suctioning without withdrawal of the instrument.

The skill of rigid thoracoscopy was easily learnt. Rigid instruments are less expensive, have a longer endurance, and may need maintenance and repair less often. In addition, it can also provide sufficient materials from forceps biopsy specimens to perform most histological tests including immunohistochemical staining in a patient with malignant pleural mesothelioma.

When biopsy specimens obtained with the two instruments were compared (Table 1), the histological features were considered identical in 25 patients, the specimens obtained with the fibreoptic bronchoscope were more informative in two patients, and those obtained from the rigid thoracoscope were more informative in 13 patients.

In five patients, the specimens obtained with the rigid thoracoscope changed the diagnosis from fibrinous pleurisy to the following: metastatic carcinoma in three patients, mesothelioma in one and caseating granuloma in another.

In another five patients, adequate biopsies could not be obtained with fibreoptic bronchoscopy forceps, whereas biopsies with rigid thoracoscope forceps in same patients were adequate, two of them were diagnosed as metastatic carcinoma and the other three were reported as fibrinous pleurisy among which one patient (remained idiopathic) had apparently normal pleura that was very smooth, this caused sliding of the flexible forceps and was difficult to biopsy except with the rigid forceps. Extensive adhesions were present in another patient. The biopsies were inadequate either due to very small size average (1×1 mm) or insufficient depth.

In three patients, flexible bronchoscopy yielded hesitant results (suspicious of malignancy), these were confirmed to be metastatic carcinoma after rigid thoracoscopy.

On the other hand, the fibreoptic instrument provided better biopsy material in two patients: one diagnosed as metastatic non small cell carcinoma in which the rigid thoracoscope could not be introduced due to extensive adhesions and lack of adequate pleural space due to failure of lung to collapse, and in another patient biopsy material showed

fibrinous pleurisy by flexible thoracoscopy while the biopsy material of the rigid thoracoscope only showed crushed tissues, this patient was finally diagnosed as tuberculous pleurisy after adding results of bacteriology.

Note that the terms inadequate biopsy or suspicious lesion were only encountered on using the flexible bronchoscope as a thoracoscope.

Although the ability of medical thoracoscopy (MT) to provide specific histopathological diagnosis for cancer and tuberculous pleurisy is quite high, a considerable amount of patients who undergo MT are diagnosed with fibrinous pleuritis because all benign pleural pathologies, excluding pleural tuberculosis, provide a diagnosis of fibrinous pleuritis [31]. Studies assume that, if the histology report of the pleural tissue revealed any of the following, they identified these cases as fibrinous pleuritis: reactive fibrous pleural thickening, fibrinous pleurisy, fibrosis, fibrous connective tissue, chronic inflammation, benign changes in the absence of malignant pleural infiltration, pleural vasculitis or evidence of bacterial infection [30]. In our study, and according to this definition, we found that the term fibrinous pleurisy as a histological diagnosis which represents a diagnostic dilemma to the pulmonologist as well as the patient was more common on using the flexible thoracoscope (16 versus 13 using the rigid thoracoscope, i.e. 40% versus 32% of studied patients respectively). A recent study showed that the rate for fibrinous pleuritis diagnosis was 31%, with a false-negative rate for malignancy of 12% [32]. Others report that the rate of MT samples histopathologically determined to be “fibrinous pleuritis” varies between 9% and 50% [33]. Among these patients, false negatives range between 5% and 25.5% for malignant pleural disease [8,34]. Adding bacteriological results aided so much in reaching appropriate diagnoses among these patients as follows: one patient with septic pleurisy proved to be tuberculous empyema confirmed within 24 h using Bactalert. The 13 patients histologically reported as nonspecific pleurisy by rigid thoracoscope, showed the following; culture results showed pseudomonas in one patient, who responded adequately to appropriate antibiotics as suggested by the culture sensitivity results, nine patients were diagnosed as tuberculous pleurisy ($9/13 = 70\%$). Of the three other patients, after follow up and further investigations, one proved to be malignant by repeating cytology [false negative (8%)], one was diagnosed as brucellosis and only one remained idiopathic and was lost during follow up. Thus our results underscore the vital role of routine microbiological examination of all thoracoscopic pleural biopsy specimens.

Regarding diagnosis of tuberculous pleurisy, excluding those with combined malignancy and tuberculous pleurisy, tuberculous effusion was the sole diagnosis in 35% of our patients. This is in stark contrast to the findings of Kendall [35] who did not find any case of TB in their study of 48 patients undergoing thoracoscopy for undiagnosed pleural effusions. This was probably due to low prevalence of TB in the West. On the other hand, two studies carried out recently in our department [36,37] showed diagnosis of tuberculous pleurisy in 19.5% and 11.7% of studied patients, respectively using histopathology alone. We attribute the high incidence in our study to subjecting all patients to a routine thorough bacteriological examination including acid fast staining on direct smear and/or after cytopspin technique, PCR, conventional culture for tuberculosis and Bactalert in some of the patients. In addition, the

low socioeconomic class of our patients, and the fact that 37.5% of our patients were diabetics might have aggravated this finding. MT has a high histological and bacteriological yield in cases of tuberculous pleurisy [15]. The ability to visualise major portions of the pleural surface, to intervene in the presence of membranes and septae with the option of numerous dedicated biopsies ensures optimum diagnostic results that are reflected by a yield of 94–99% in the literature [10,25,38–40].

Pleurisy incidence obviously parallels variability of global TB prevalence with an overwhelming share of 95% occurring in developing countries. In TB-patients as a whole, pleural involvement varies between ~3 and 5% in Western Europe and the USA versus ~30% in developing, HIV-high-prevalence-countries [41–43]. Egypt is ranked by the WHO as a country with middle/low level of tuberculosis (TB) incidence. It is estimated that 11 cases per 100,000 population develop active pulmonary smear positive TB annually, while 24 per 100,000 develop all types of TB annually [44].

It is also important to note that the microbiologist preferred larger biopsies obtained by the rigid forceps using rigid thoracoscope for direct smear staining for acid-fast bacilli. After combining both histological and bacteriological examinations of biopsy specimens, our study showed a higher diagnostic yield when a rigid thoracoscope was compared to a flexible fiberoptic thoracoscope, (38/40) (95%) versus (32/40) (80%). False negative diagnosis for malignancy was obtained in only one patient using rigid thoracoscope and failure of introduction occurred in another patient. On the other hand, the flexible thoracoscope yielded false negative results for malignancy in seven patients. Other studies showed variable diagnostic yield; in a prospective study on 40 patients from South Africa, thoracoscopy had a diagnostic yield of 98% [45]. Kendall [35] reported yield of thoracoscopic pleural biopsy to be 83% in their study in the United Kingdom. Ng [46] achieved diagnosis with thoracoscopic pleural biopsy in 45.5% (10/22) patients with undiagnosed pleural effusions. Tscheikuna [47] reported that thoracoscopy was diagnostic in 95% of 34 patients.

Eventually, after combining the results of both histopathological and microbiological examinations of specimens from both types of thorascopes, observing clinical course of the patient, adding additional investigations as needed, the final diagnosis was reached in 39 out of the 40 studied patients (97.5%). Only one patient in our study remained idiopathic.

Finally, we conclude that the rigid thoracoscope is obviously superior to the flexible one providing a higher confident diagnostic yield with little if any more discomfort or complications. Still if rigid thoracoscope was not available, flexible thoracoscope might provide a diagnosis when less invasive measures have failed to do so, reducing the need for the more invasive and much more expensive thoracotomy.

Conflict of interest

The authors declare that there is no conflict of interest.

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